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Outline capturing using rational functions with the help of genetic algorithm

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ABSTRACT

A technique to capture outline of planar objects using two rational cubic functions for approximating the boundary curve, is presented in this paper. Genetic algorithm is utilized to find suitable values of parameters in the description of rational functions. The proposed devised scheme eventually helps construct optimal curve to contours of images of generic shapes.

1. Introduction

Computer Aided Geometric Design (CAGD) is a field of study which deals with computational features of shapes by means of different techniques and algorithms. Spline functions are effectively used in CAGD, computer graphics, geometric modeling, designing curves and surfaces, because of their flexible attributes.

The paper intents for an optimum curve to the data generated by boundary of bitmap images. The techniques presented by authors in [4,6–9,13–15,17–21] use spline functions, associated tangent vectors and subdivision of curve to achieve optimal curves. Some proposed techniques dynamically discover interior knots by genetic algorithm [11,12]. In [16] authors calculated the ratio between two intermediate control points and used this to estimate their position.

In this paper, an innovative scheme is suggested, composed of various phases, for fitting the curve that globally optimizes values of shape parameter in the description of rational functions and extends the list of corner points to larger set of points which are intermediate points. The scheme proposed, uses rational cubic functions, having one and two shape parameters in their account. These shape parameters help to control the shape of curve between knots and the curve gets tighten or loosen according to requirements with the help of these parameters. The suitable values of these shape parameters are found using genetic algorithm [2,3]. The motive behind using genetic algorithm instead of direct least square method is that, in case of rational functions, evaluation of parameters through sum squared error is quite hard and complicated. In comparison genetic algorithm is simple to implement for that particular purpose.

The organization of paper is as follows. Section 2 includes steps of extracting boundary, corner detection, rational functions, parameterization and estimation of tangent vectors. Genetic algorithm is discussed in Section 3. Section 4 describes overall proposed approach including pictorial results of all iterations when applied on symbol of kanji. The scheme is demonstrated pictorially in Section 5 and comparative study and conclusion are given in Sections 6 and 7 respectively.

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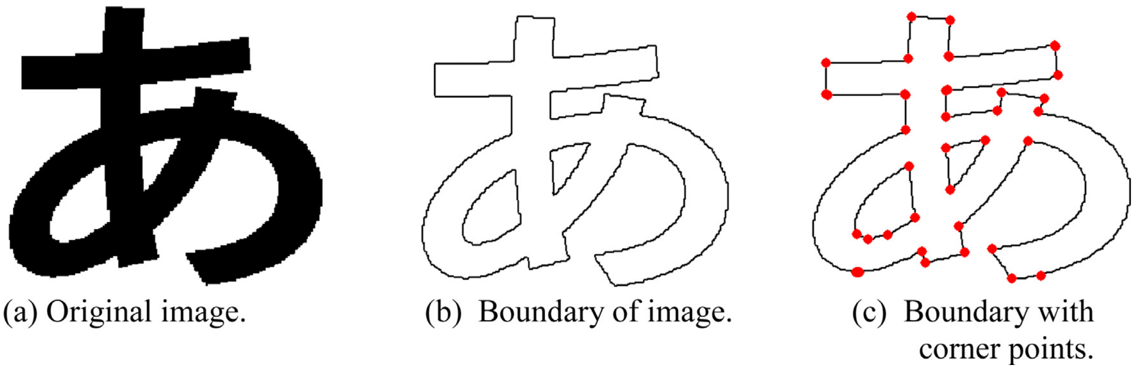

Fig. 1. (a) bitmap image of a plane, (b) detected boundary of the image (c) detected corner points from the boundary.

Table 1
Name and details of image.

Image	Name	# of contours	# of contour points	# of corner points
	Kanji.bmp	3	[1731 + 214 + 152] = 2097	[33 + 5 + 3] = 41
	Music.bmp	1	1452	7
	Mu.bmp	1	832	11
	Kaf.bmp	2	[317 + 129] = 446	[7 + 6] = 13

2. Curve fitting with rational function

The objective is to configure a curve that gives best fit to the data produced by boundary of image of planar objects. The suggested scheme comprises various phases like boundary detection, finding significant points and then fitting curve by means of genetic algorithm and rational cubic functions and finally, introducing intermediate points between knots (corner points) wherever required.

2.1. Boundary detection

Boundary is detected to generate shape of planar objects in graphical representation. Most often used technique for extracting boundary is described in [23]. The technique takes object's image as input. Then for each edge of contour, chain codes corresponding to direction of edges are extracted. This chain coded curve gives boundary of image as output.

2.2. Detecting corner points

Corners are beneficial as they provide rough sketch about shape of an image. The technique used in this paper for corner detection is described in [1] in which corner strength is associated at each point of boundary. The algorithm comprises of two stages. In the first stage, it finds candidate corners from whole data set while in second stage some extra points are discarded using certain criteria giving only potential corners.

These are important to find as they partition the data in segments. After breaking the data into different segments, data values can be represented as $P_{i,j} = (x_{i,j}, y_{i,j}),\ i = 1, 2, \ldots, n,\ j = 1, 2, \ldots, m_i$, where n is number of segments and m_i is number of data points in ith segment. Then $P_{i,j}$is the jth point of ith segment. A bitmap image together with its boundary and corners are shown in Fig. 1 ((a), (b), and (c)) respectively. Table 1 gives number of contour points and number of detected corner points for different images.

2.3. Rational cubic functions

For fitting curve, piecewise rational cubic functions [5,22] are used which are described with their properties in this section.